SUMMARY OF COURSES

[From the AY 2018-2019]

Sub Discipline: DEPARTMENTAL CORE

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MAC01	MATHEMATICS 1	3-1-0	4	
MAC02	MATHEMATICS 2	3-1-0	4	
MAC331	MATHEMATICS 3	3-1-0	4	

Basket of Open Elective-1 [4th semester]

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MAO441	Discrete Mathematics	3-0-0	3	
MAO442	Probability and Stochastic Processes	3-0-0	3	

Basket of Open Elective-2 [5th semester]

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MAO541	Mathematical Methods for Engineers	3-0-0	3	
MAO542	Linear Algebra	3-0-0	3	
MAO543	Modern Algebra	3-0-0	3	

Basket of Open Elective-5 [8th semester]

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MAO851	Operations Research	3-0-0	3	
MAO852	Advanced Numerical Analysis	3-0-0	3	
MAO853	Optimization Techniques	3-0-0	3	

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Basic concepts of function, limit, differentiation and integration.					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, center of mass, center of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, Change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)						
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Daniel A. Murray, Differential and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Edition, Addison Wesley.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAC 02</td><td>MATHEMATICS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Basic concepts of set theory, differential equations and probability.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
• CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
• CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
• CO4: To grasp the basic concepts of probability theory.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Elementary algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (5)

Linear Algebra: Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)

Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12)

Fourier series: Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)

Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations.

Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10)

Probability: Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. E. Kreyszig, Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010).
2. Gilbert Strang, Linear algebra and its applications (4th Edition), Thomson (2006).
3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Edition (2017).

Reference Books:
1. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India (2000).
2. C. Grinstead, J. L. Snell, Introduction to Probability, American Mathematical Society.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	MATHEMATICS-III	PCR	3	1	0	4	4
Pre-requisites		Basic knowledge of topics included in MAC01 & MAC02					

Course Outcomes	• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. • CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. • CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. • CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.
Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]

Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC331	CO1	3	3	3	2	2	1	2	-	-	-	-	2
	CO2	3	3	2	2	2	1	2	-	-	-	1	2
	CO3	3	3	2	2	3	-	1	-	-	1	-	2
	CO4	3	2	2	3	2	1	1	-	1	-	-	2

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAO441</td><td>Discrete Mathematics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid-term assessment (MA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Set Theory</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To enable the students to apply the basic concept of Logic to solve engineering and Artificial Intelligence related problems.
• CO2: To enable the students to solve problems of combinatorics.
• CO3: Students will have knowledge of Graph Theory which arises in many engineering and physical problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction to set theory; combination of sets; power sets; finite and infinite sets, Introduction to Combinatorics, Counting techniques, The inclusion-exclusion principle, The pigeon-hole principle and its applications, Recurrence relation, Generating function, Partial order relations; POSETS.
[6]
2. Mathematical logic, Predicate logic, Basic logical operation, Truth tables, Logic proposition and proof, Notion of interpretation, Method of proofs, Validity, consistency and completeness.
[6]
3. Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates, Different forms of the principle of mathematical induction.
[5]
4. Relations, Equivalence relation and equivalence classes, Diagraphs, Computer representation of relations, Warshall’s algorithm, Representations of relations by binary matrices and digraphs; operations on relations. Closure of a relations; reflexive, symmetric and transitive closures.
[7]
5. Lattice Theory and Introduction to Boolean algebra and Boolean functions, Different representations of Boolean functions, Application of Boolean functions to synthesis of circuits, Composition of function, functions for computer Science, Permutation function and growth of functions.
[5]
6. Introduction of discrete numeric functions, Asymptotic behavior, Generating functions, Linear recurrence relations with constant coefficients (homogeneous and non-homogeneous cases), Solution of linear recurrence relations using generating functions.
[5]
7. Path, cycles, Handshaking theorem, Bipartite graphs, Sub-graphs, Graph isomorphism, Operations on graphs, Eulerian graphs and Hamiltonian graphs, Planar graphs, Euler formula, Traveling salesman problem, Shortest path algorithms, Minimum spanning tree algorithms, Maximum flow algorithms.
[7]</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. Discrete Mathematics and its Applications - Kenneth H. Rosen 7th Edition -Tata McGraw Hill Publishers – 2007. 2. Elements of Discrete Mathematics, C. L Liu, McGraw-Hill Inc, 1985. Applied Combinatorics, Alan Tucker, 2007. **Reference Books:** 1. Concrete Mathematics, Ronald Graham, Donald Knuth, and Oren Patashnik, 2nd Edition - Pearson Education Publishers - 1996. 2. Combinatorics: Topics, Techniques, Algorithms by Peter J. Cameron, Cambridge University Press, 1994 (reprinted 1996). Topics in Algebra, I.N. Herstein, Wiley, 1975.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO441	CO1	3	3	3	2	3	2	1	-	-	-	1	2
	CO2	3	2	3	3	2	1	1	-	1	-	1	1
	CO3	3	3	2	3	2	2	2	1	-	1	3	1

Correlation levels 1, 2 or 3 as defined below:
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Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO442	Probability and Stochastic Processes	PEL	3	0	0	3	3
Pre-requisites		Knowledge of differential and integral calculus, basics of probability at MAC02					

Course Outcomes	• CO1: To provide the basics of probability theory. • CO2: Introduce to students the probability models in physics, engineering, biology etc. • CO3: To highlight the roles of stochastic processes in physics, social science, finance etc.
Topics Covered	**Introduction:** Axiomatic definition of Probability, Conditional Probability and Multiplication Rules, Stochastic independence, Baye's theorem and applications. (8) **Random Variables & Probability Distribution:** Random variables: Discrete and continuous, discrete and continuous probability distributions, Binomial and Poisson distribution, Normal distribution, Exponential distribution, Joint probability distributions, bivariate normal distribution. (6) **Mathematical Expectation:** Expectation of random variable, Properties of Expectation, Variance and covariance of random variables, Means and variances of Linear Combinations of Random Variables, Conditional Expectations. Correlation coefficient. (6)

	Functions of Random Variable: Transformation of Variables, Moments and Moment Generating Functions, Characteristics functions, Normal Approximation to Binomial. (6) **Stochastic Processes:** Stochastic Process: definition and examples, Stationary Processes, Auto correlation, Auto Covariance, cross correlative coefficient, Martingales. (6) **Markov Chains**: Definitions and examples of Markov chains, Chapman- Kolmogorov Equations & classification of states, Ergodic Markov Chain, Applications of Markov chains, Time reversible Markov chains. (6) **Poisson Process**: Poisson Process, Inter-arrival & waiting time distributions, Non-homogeneous Poisson Process, Conditional Poisson process. (4)
Text Books, and/or reference material	**Text Books:** 1. T. Veerarajan: Probability, Statistics and Random Process, Tata McGraw-Hill Education, 2002. 2. Ronald E Walpole and Raymond H Myers: Probability and Statistics for Engineers and Scientists 3. J. Medhi, Stochastic Process, Wiley Eastern Limited, Second Edition, 1994. **Reference Book:** 1. C. Grinstead and J. Snell, Introduction to probability, American Mathematical Society, 1997. Roy D Yates and David J. Goodman, Probability and stochastic processes, John Wiley and Sons, 1998.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO442	CO1	3	3	3	3	2	1	-	1	1	1	1	1
	CO2	3	3	3	3	3	-	-	-	-	-	-	-
	CO3	3	3	3	3	3	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
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Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO541	Mathematical methods for engineers	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-term assessment (MA) and end assessment (EA))					
MAC02 (Mathematics-II)		CT+EA					

Course Outcomes	• CO1: Students will be able to understand and solve the difference equations that are used to model various engineering problems. • CO2: To enable the students to apply integral transforms to problems formulated on finite or infinite domains and also to solve engineering and physical problems involving PDEs in a simpler way using integral transforms. • CO3: To enable the students to solve a discrete systems using Z- Transform. • CO4: Students will have an in-depth knowledge of power series solution of differential equations and also will learn about special functions which arise in many engineering and physical problems.
Topics Covered	**Difference Equations:** Formation of difference equation, First and higher order difference equations, Reduction of non-linear difference equation into linear form, Solution of difference equations. (6) **Z-transform:** Some standard Z- transforms, Properties of Z-transform, Damping rule, Shifting rule, Initial and final value theorem, Convolution theorem, Inverse Z-transform, Solution of difference equations using Z-transform. (6) **Series Solution of Ordinary Differential Equations:** Validity of series solution, Series solution about an ordinary point and about a regular singular point, Bessel's equation and Bessel functions, Recurrence relations of Bessel functions, Generating function for $J_n(x)$, Orthogonality of Bessel functions, Legendre's equation and Legendre functions, Legendre polynomial, Rodrigue's formula, Generating function for $P_n(x)$, Recurrence relations for $P_n(x)$, Orthogonality of Legendre polynomial. (15) **Application of Fourier Transforms:** recapitulation of Fourier transform & its properties, solution of partial differential equations using Fourier transform (6) **Application of Fourier Transforms in mathematical statistics** (2) **Finite Fourier Transforms:** Finite Fourier Sine & Cosine transform, basic properties, applications of finite Fourier Sine & Cosine transform in the solution of boundary value problems (7)
Text Books, and/or reference material	**Text Books:** 1. S. L. Ross: Differential Equations: John Willey and Sons. 2. I. N. Sneddon: The use of Integral Transforms, McGraw-Hill, 1974. 3. E. Kreyszig: Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). **Reference Books:** 1. M.D. Raisinghania: Advanced differential equations: S. Chand Publication. 2. L. Debnath & D. Bhatta: Integral Transforms and their applications: 2nd Edition, Chapman & Hall/CRC.

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO541	CO1	3	3	3	2	1	1	1	-	1	1	-	2
	CO2	3	3	2	2	1	1	1	-	1	1	-	2
	CO3	3	2	2	2	2	1	1	-	1	1	-	3
	CO4	3	2	2	2	2	1	1	-	1	1	1	3

Department of mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO542	Linear Algebra	PEL	3	0	0	3	3
Pre-requisites		MAC02					
Course Assessment methods (Continuous (CT) and end assessment (EA))		CT+EA					
Course Outcomes	• CO1: Solve systems of linear equations using several methods, including Gaussian elimination and matrix inversion • CO2: Demonstrate understanding of the concepts of vector space and subspace, linear independence, span, and basis and use these for analysis of matrices and systems of linear equations. • CO3: Determine eigenvalues and eigenvectors and solve eigenvalue problems; apply principles of matrix algebra to linear transformations; discriminate between diagonalizable and non-diagonalizable matrices; demonstrate understanding of inner products and associated norms.						
Topics Covered	• Systems of linear equations, Matrices, Elementary row and column operations, Row-reduced echelon matrices., Gaussian elimination, LU-Decomposition. (6) • Vector spaces, Subspaces, Linear span, Linear dependence and independence, Basis and dimension, Ordered basis and coordinates, Row space and column space, Direct-sum decompositions. (12) • Linear transformations, Rank-Nullity theorem, Matrix representation of linear transformations. (7) • Eigenvalues and eigenvectors, Cayley-Hamilton theorem, Diagonalization of Matrices, Minimal polynomial, Rational canonical form, Jordan canonical form. (13) • Inner Product Spaces, Orthonormal Basis, Gram-Schmidt Theorem. (4)						
Text Books, and/or reference material	**Text Books:** 1. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall of India, New Delhi, 1990. 2. S. K. Mapa, Higher Algebra, Sarat Book Distribution, 2000. **Reference Books:** 1. S. Lang, Linear Algebra, Springer, Third Edition. 2. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning Pvt. Ltd., 2000.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO542	CO1	3	2	1	-	1	-	1	1	-	-	-	2
	CO2	3	3	1	1	1	-	1	-	-	-	-	2
	CO3	3	3	2	1	1	1	1	-	1	1	1	2

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Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO543	Modern Algebra	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire an idea about abstract mathematical problems • CO2: To understand the principle of symmetric objects • CO3: To learn the basic tools of vector spaces, coding theory and cryptography						
Topics Covered	Preliminary concept: Sets and Equivalence relations and partitions, Division algorithm for integers, primes, unique factorizations, Chinese Remainder Theorem, Euler ϕ-function. [10] Groups: Cyclic groups, Permutation groups, Isomorphism of groups, Cosets and Lagrange's Theorem, Normal subgroups, Quotient groups, Group homomorphisms, Cayley's theorem, Cauchy's theorem. [12] Rings: Ideals and Homomorphism, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Polynomial Rings. [10] Fields: Vector space, Field extensions, Finite Fields. [10]						
Text Books, and/or reference material	**Text Books:** 1. *J. B. Fraleigh, A First Course in Abstract Algebra,* Addison Wesley, 2013. 2. *I. N. Herstein, Topics in Abstract Algebra,* Wiley Eastern Limited, 1975. **Reference Books:** 1. *T. W. Hungerford, Algebra, Springer*, 2009. **2.** *D. S. Dummit, R. M. Foote, Abstract Algebra,* Second Edition, John Wiley & Sons, Inc., 1999. **3.** *G. A. Gallian, Contemporary Abstract Algebra,* Narosa Publishers, 2017.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO543	CO1	3	3	2	2	1	-	1	1	-	-	1	1
	CO2	3	3	1	1	1	1	1	-	-	-	-	-
	CO3	3	2	1	3	2	-	-	-	1	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO851	Operations Research	PEL	3	0	0	3	3
Pre-requisites		Basic concepts of Set Theory, Linear Programming Problem, Network and Game Theory					
Course Outcomes	• CO1: To understand the origin of Operations Research and &to familiarise with formulation of different Problems. • CO2: To acquire knowledge on fundamentals of Linear Programming and also to learn its applications. • CO3: To get basic knowledge on fundamentals of Netwok Analysis so as to get acquainted with designing & planning of various project related problems. • CO4: To get the basic Concepts of decision making under competitive situations.						
Topics Covered	**Overview of Operations Research:** Origin of OR and its definitions, Formulation of the OR problems, Developing OR models, Testing the adequacy of the model, Model solution, Evaluation of the solution and implementation. (4) **Linear Programming and its Applications:** Vector spaces, Basis, Linear transformations, Convex sets, Extreme points and convex polyhedral sets Theory of Simplex method, Simplex Algorithm, Degeneracy, Duality theory, primal dual algorithms, Transportation problems, Assignment problems, Sensitivity analysis. (14) **Network Analysis:** Introduction to network analysis, Shortest path problem, Construction of minimal spanning tree, Flows in networks, Maximal flow problems. Definition of a project, Job and events, Construction of arrow diagrams, Determination of critical paths and calculation of floats. Resource allocation and least cost planning, Use of network flows for least cost planning. Uncertain duration and PERT, PERT COST system. Crashing. (12) **Game Theory:** Maxmin and Minmax principle, Two-person Zero-sum games with saddle point, Game problems without saddle point, Pure strategy and mixed strategy, Solution of a 2×2 game problem without saddle point, Graphical method of solution for n×2 and 2×n game problem, Reduction rule of a game problem (Dominance rule), Algebraic method of solution of game problem without saddle point, Reduction of a game problem to linear programming problem. (12)						
Text Books, and/or reference material	**Text Books:** 1. J. K. Sharma: Fundamentals of Operations Research, Macmillan. 2. F.S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995. 3. Ravindran, Philips, Solberg, Operations Research Principles and Practices, Wiley India Edition. **Reference Books:** 1. Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research- An Introduction, S. Chand & Company. 2. Anderson, D. R., Sweeney, D. J. and Williams, T. A., An Introduction to Management Science, St. Paul West Publishing Company, 1982. 3. Sharma, S. D., Operations Research, Kedar Nath and Ram Nath, Meerut, 1995. 4. H. A. Taha, Operations Research –An introduction, PHI						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO851	CO1	2	3	2	2	1	1	1	-	-	-	1	2
	CO2	2	3	2	1	1	2	2	-	1	2	2	2
	CO3	3	3	2	3	1	-	1	-	2	2	2	2
	CO4	2	2	3	1	2	2	2	1	2	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total contact hours (Per week)</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAO852</td><td>Advanced Numerical Analysis</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basics of Linear Algebra & Numerical Methods</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Develop problem solving skills by different numerical methods and also skill in numerically verifying theoretical convergence speed.
• CO2: Help to work with key concepts of stability and assessing the accuracy of numerical results.
• CO3: Help to write algorithm, computational steps & flow chart which help in developing computer program.
• CO4: Help to solve various scientific and engineering problems by different numerical methods.</td></tr>
<tr><td>Topics Covered (with lecture hours)</td><td colspan="7">Numerical solution of Algebraic and transcendental equations (Method of Iteration, Newton-Raphson method), convergence and errors. (3)

Solution of system of equations by Direct method (Gauss-elimination, Gauss Jordon, L-U decomposition) and Iteration method (Jacobi, Gauss-Seidel), Convergence analysis and errors. (7)

Eigen values and Eigen vectors by power method. (3)

Interpolation- Newton’s divided difference, cubic spline, Hermite poly, error in interpolation, Least square approximation. (6)

Numerical differentiation and integration (Trapezoidal rule, Simpson’s 1/3rd rule, Simpson’s 3/8th rule), Error analysis. (5)

Numerical solution of ordinary differential equations (Taylor series method, Euler’s & Modified Euler’s method, Runge-Kutta method), Finite difference solution of boundary value problem. (9)

Numerical solution of partial differential equations of hyperbolic (wave equation), parabolic (heat equation), elliptic (Laplace and Poisson equation) type. (9)</td></tr>
<tr><td>Text Books, and/or reference books</td><td colspan="7">Text Books:
1. Introductory Methods of Numerical Analysis- S.S.Sastry (PHI).
2. Numerical Methods for scientific & Engineering Computation- M.K. Jain, S.R.K. Iyengar & R.K. Jain (New Age International (P) Ltd.).
Reference Books:
1. Numerical Mathematical Analysis- J.B. Scarborough (Oxford & IBH).
2. A friendly introduction to Numerical Analysis- Braine Bradie (Pearson Education).</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO852	CO1	3	3	2	2	3	1	2	-	-	3	1	2
	CO2	2	3	2	2	1	2	1	1	1	2	1	2
	CO3	2	2	1	1	-	-	1	-	-	1	-	2
	CO4	3	2	2	2	2	2	2	-	2	3	2	3

<table>
<tr><td colspan="7">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAO853</td><td>Optimization Techniques</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Vector Spaces and Matrices, Linear Transformations, Eigenvalues and Eigenvectors</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Ability to develop a knowledge in the field of optimization techniques and their basic concepts, principles and algorithms.
CO2: Ability to understand fundamentals of linear programming, Integer programming and Dynamic programming.
CO3: Ability to apply the theory of optimization methods for modelling various types of decision making problems.
CO4: Ability to solve the mathematical results and numerical algorithms of optimization theory to concrete Engineering and Management problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Basic Concepts: Formulation of mathematical programming problems; Classification of optimization problems; Optimization techniques – classical and advanced techniques (5)

Optimization using Calculus: Convexity and concavity of functions of one and two variables; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation (7)

Linear Programming: Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Graphical method for two variable optimization problem; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Revised simplex method; Duality in LP; Primal dual relations; Dual Simplex Method; Sensitivity or post optimality analysis; bounded variables; Examples for transportation, assignment, TSP problems. (18)

Dynamic Programming: Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality (8)

Integer Programming: Integer linear programming; Branch and Bound algorithm; Concept of cutting plane method; Mixed integer programming; Solution algorithms. (8)

Advanced Topics in Optimization: Direct and indirect search methods; Heuristic and Meta-Heuristic Search methods; Multi objective optimization. (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Singiresu S. Rao, Engineering Optimization -Theory and Practice, New Age International (P) Limited, New Delhi, 2000.
2. H.A. Taha, Operations Research: An Introduction, 5th Edition, Macmillan, New York, 1992.
A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, Engineering Optimization-Methods and Applications, Wiley-India Edition, New Delhi, 2002.

Reference Books:
1. R. Fletcher, Optimization, Academic Press, 1969.
2. 2. K. Deb, Optimization for Engineering Design Algorithms and Examples, Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO853	CO1	2	3	3	2	1	1	2	-	1	-	1	1
	CO2	2	2	3	1	2	-	3	-	1	-	2	1
	CO3	3	2	2	2	2	-	2	-	1	1	2	2
	CO4	3	2	3	3	2	-	3	-	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:
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